(12) UK Patent Application (19) GB (11) 2 271 228 (13) A

(43) Date of A Publication 06.04.1994

(21) Application No 9320079.8

(22) Date of Filing 29.09.1993

(30) Priority Data
(31) 924426 (32) 01.10.1992 (33) FI

(71) Applicant(s)
FPS Power Systems OY AB

(Incorporated in Finland)

Koskelontie 14, FIN-02920 Espoo, Finland

(72) Inventor(s)
Lennart Jonsson

(74) Agent and/or Address for Service
Mathisen Macara & Co
The Coach House, 6-8 Swakeleys Road, Ickenham,
UXBRIDGE, Middlesex, UB10 8BZ, United Kingdom

(51) INT CL[5]
H02J 7/04 , G01R 31/36 , H02J 9/06

(52) UK CL (Edition M)
H2H HAJ HBCA HBCD HBCG HBCJ H21R H22G H25G
H2K KSX K255 K453 K55Y K552 K76Y
U1S S2078 S2123

(56) Documents Cited
GB 2248735 A GB 2091502 A GB 2084817 A
GB 1349079 A EP 0209269 A2 US 5185536 A

(58) Field of Search
UK CL (Edition L) H2H HAJ HBCD
INT CL[5] H02J 7/02 7/04 7/06 7/08 7/10 7/12 9/00 9/02 9/04 9/06

(54) **Controlling charging of a battery in an uninterruptible power supply**

(57) Under normal conditions a load 3 is energised from a main power supply 5 and a battery 1 is disconnected both from the load 3 and from a charger 7, the battery 1 being charged in response to its open circuit voltage falling to a minimum limit value (V1, Fig 3). Charging is also initiated after a mains interruption, and if the battery internal impedance increase to a predetermined level during discharge via an inverter 2 to load 3. The internal impedance is determined on the mains of the load current and the A.C. component of the battery voltage (which is due to the load current).

Charging is initially effected at constant current until the battery voltage rises to a reference level, and then at constant voltage for a predetermined time (Fig. 3).

An alarm is raised if the battery intense impedance increaser to the predetermined level during discharge to the load, and if self-discharge of the disconnected battery causes its open circuit voltage to fall to the limit value (V1) in too short a time (indicative of a faulty battery). Shutdown of the load 3 may also be initiated if the battery internal impedance increases to the predetermined level.

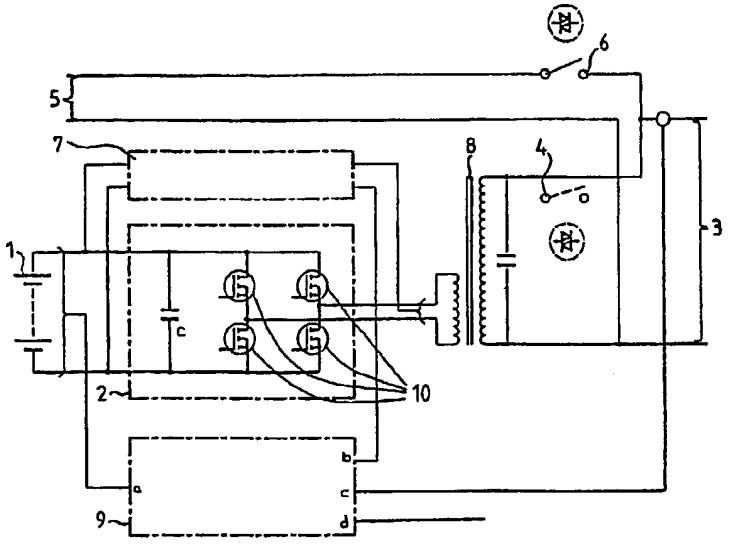

FIG. 2

GB 2 271 228 A

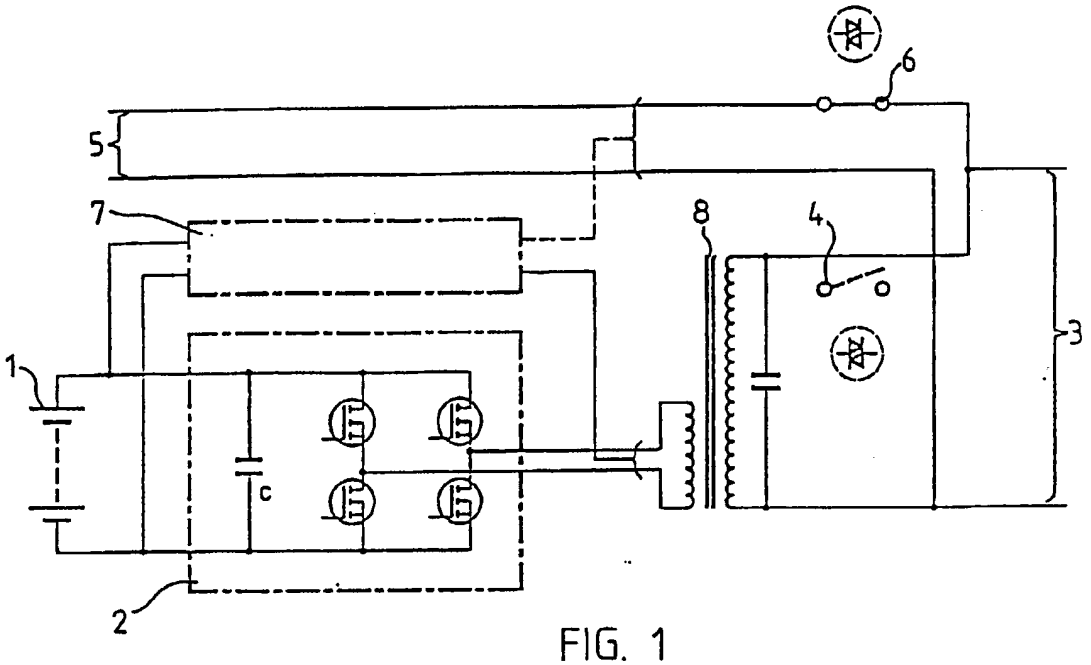

FIG. 1

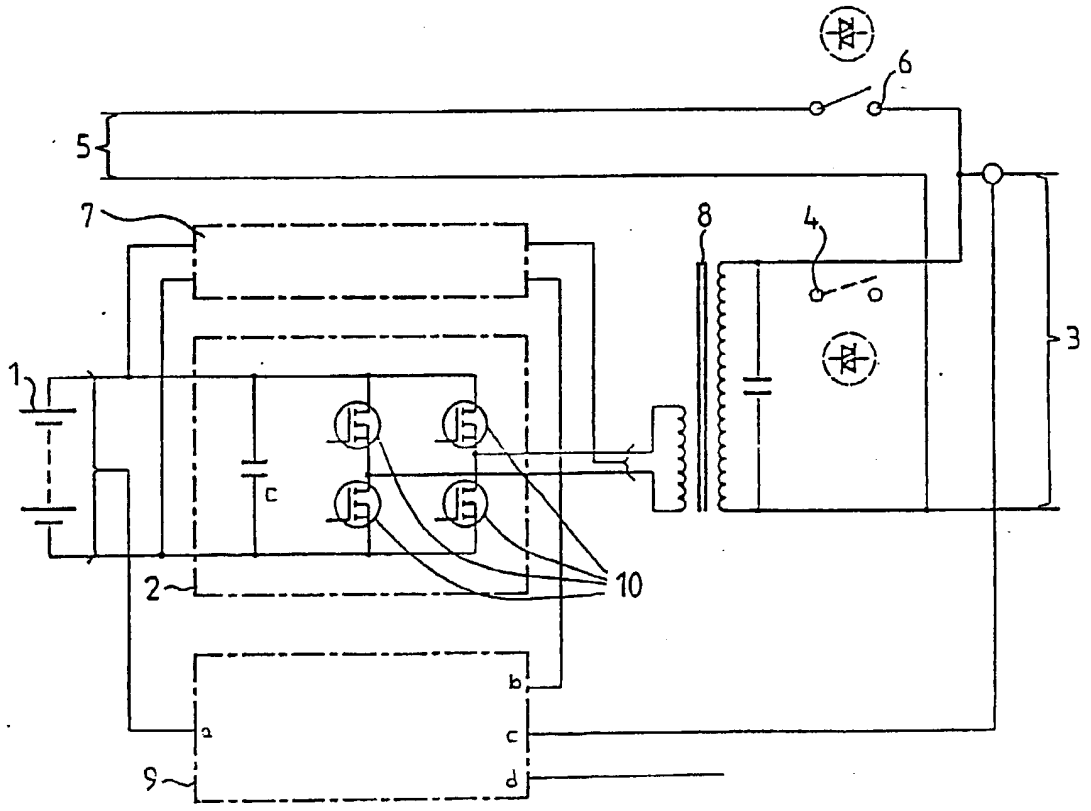

FIG. 2

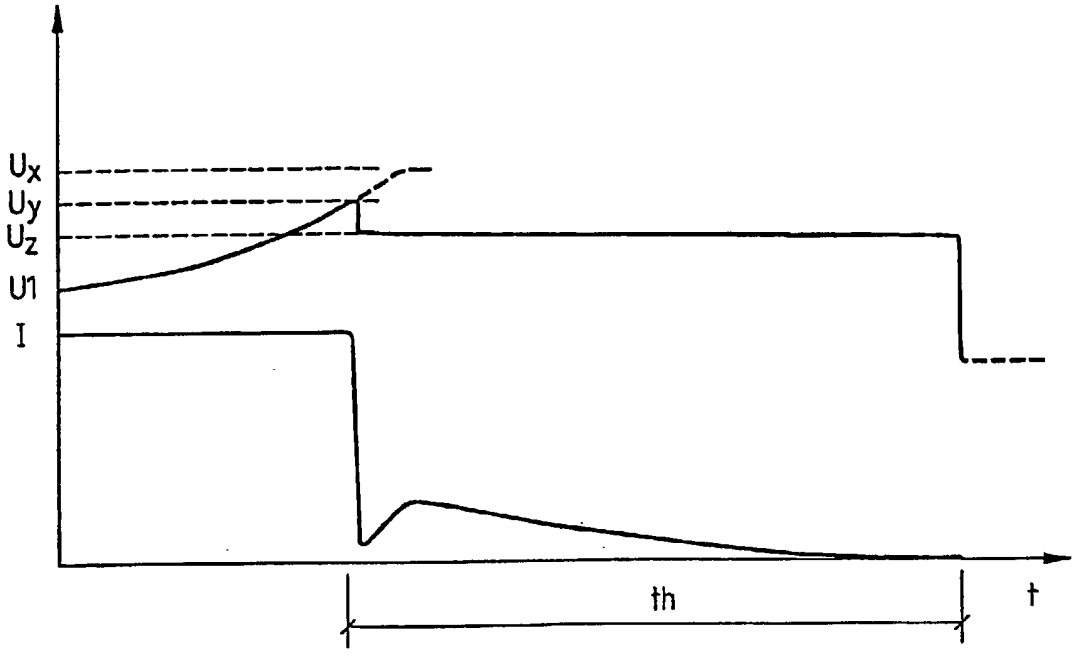

FIG. 3

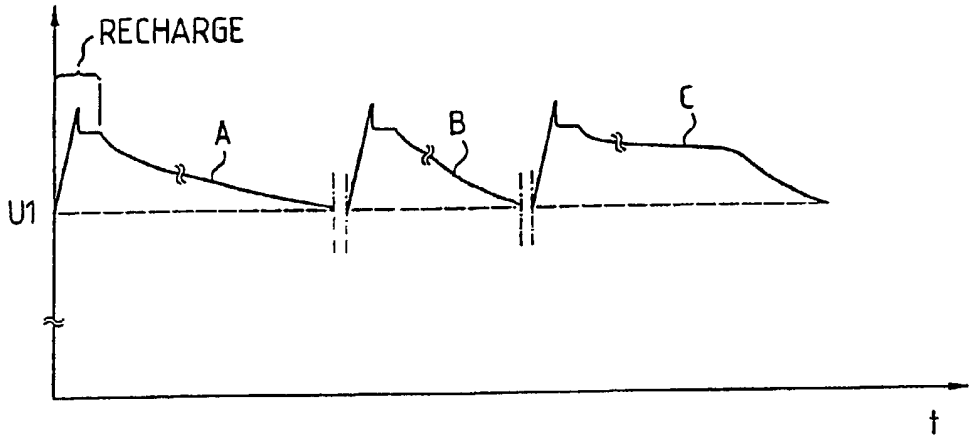

FIG. 4

A method of controlling and maintaining the charge in an accumulator battery in an uninterruptible power supply, and an uninterruptible power supply

The present invention relates to a method of controlling and maintaining the charge in an accumulator battery in an uninterruptible power supply wherein the battery is disconnected from the load under normal conditions, and an uninterruptible power supply.

In uninterruptible power supplies (UPS) for computers and other apparatus that are sensitive to power interruptions and the like, the reserve energy source in general consists of a series of lead acid cells that can be rapidly connected electronically in a case of power interruption to supply AC current via an inverter to the system connected to the UPS. The purpose of the UPS is partly to bridge shorter power interruptions, partly to signal to the data system in cases of mains interruptions of longer duration, so the computer can be shut down automatically in a controlled manner without damage, e.g. in lost files, before the limited energy stored in the battery is completely exhausted.

In certain known UPSs, the condition and charging of the battery is hardly supervised at all, but the battery is subjected to a continuous charging voltage (float charge) that must be sufficiently high to charge all cells in the battery but not so high as to overcharge any of the cells. Undercharging of the battery may result in sulphatation ($PbSO_4$) of the electrode plates in the cells. Such sulphate build-up is a normal and reversible discharge process in a lead acid accumulator, but in a continuous undercharge condition also non-recoverable sulphate crystals degrading the capacity of the battery are produced. Over-

charging may again result in drying out of the electrolytes of the battery and elevated corrosion of the electrode grids and associated conductors. Overcharging may further cause bridging phenomena finally resulting in short circuits between the electrodes. Also overheating of individual battery cells may occur, particularly with several battery cells connected in series, as variations in the individual voltages of the cells may appear.

Other known solutions utilize individual cell-voltage measurements, but the associated hardware and installation are expensive.

It is an object of the present invention to provide a method and an apparatus for achieving a suitable charge of the battery in a simple and reliable way without any risk of undercharging or overcharging. To achieve this, the method of the invention is characterized in that the voltage over the disconnected battery is measured and compared to a predetermined minimum limit value, that the battery is charged when its voltage has declined to the minimum limit value, and that the charging is discontinued when the battery has reached a certain state of charge.

The invention is thus based on a type of UPS wherein the battery is disconnected from the load under normal conditions, and the idea of the invention lies in that one can reliably measure the open cell voltage over the terminals of the battery in disconnected mode, and draw conclusions therefrom with regard to the capacity and actual charging need of the battery. This is not possible in batteries with a continuous float charge, as the terminal voltage of the battery is determined by the voltage regulator of the charger and not by the electromotive force (E.M.F.) of the battery.

Preferred embodiments of the method and UPS of the invention are set forth in the ensuing claims. In the following, the invention will be explained in more detail by means of an example with reference to the accompanying drawings, in which

Figure 1 shows a conventional UPS,

Figure 2 shows a UPS according to the invention,

Figure 3 shows an example of a charging cycle according to the invention,

Figure 4 shows a series of charging cycles illustrating how the battery condition can be monitored.

Figure 1 shows a conventional UPS wherein the battery 1 and the associated inverter 2 are normally disconnected from the output 3 of the UPS by means of a switch 4. The load is in this operational mode supplied directly from the mains supply 5. At a mains interruption, the mains supply is disconnected by switch 6, the inverter 2 is activated and connected to the load through switch 4. After mains voltage recovery, the initial state is resumed, whilst the charger 7 recharges the battery 1. The purpose of the transformer 8 is partly to transform the output voltage of the inverter into a suitable load voltage during mains interruption, partly to provide under normal conditions energy to the charger 7 for a continuous float charge of the battery 1. The switch 4 can be replaced by the switching functions of the semiconductor switches 10 in the main circuit of the inverter. A modern UPS usually also includes a logic unit performing various control functions of the different components of the UPS and providing the necessary warning signals to users of the connected system.

Figure 2 shows a UPS according to the invention, comprising as shown in Figure 1 a battery 1, an in-

verter 2, switching means 4, 6, a charger 7 and a transformer 8. The UPS further comprises a logic unit, such as a microcomputer 9, for performing the necessary control functions which will be described hereinafter. As in the apparatus of Figure 1, the battery 1 is electrically disconnected during normal operation, no current passing therethrough. Its open cell voltage (OCV) is monitored by the computer unit 9 and read at the input a. After a mains interruption, or if the OCV has declined below a predetermined value, the computer unit initiates charging of the battery by means of a signal from an output b to the charger 7.

When a mains failure occurs, the load current can be monitored by the computer unit 9 via input c. The measured value can be used as an approximation of the battery current, and thus the internal impedance of the battery can be calculated on the basis of the AC component or ripple always generated by the load current on the battery voltage when the battery is discharged to the load. When the value of the internal impedance exceeds a predetermined limit, the computer unit can initiate charging and issue an alarm of imminent battery exchange to the connected system via a connection d, and/or initiate shutting down of the connected system.

In the method of the invention, the charging of the battery is controlled according to the characteristics in Figure 3, showing the battery voltage as a function of time in charging. The charging of the battery is started with voltage U1 (t=0). The charging current I of the charger 7 is constant at this stage and would in time result in a voltage (corresponding to charging reference) of Ux volts/battery cell. When the battery voltage exceeds Uy volts/battery cell, the charging reference is altered to Uz volts/battery

cell. The charging is sustained at level Uz for a time th, whereafter the charger is turned off. In this way, overcharging of the battery is avoided.

Figure 4 shows battery charging characteristics of different kinds; A=normal battery, B=defective battery (short and steep discharging curve), and C=battery developing a faulty condition (normal curve changing into a steep, rapidly declining battery voltage). Hence the condition of the battery can be determined from the self-discharge of the battery (discharge time and rate), and an alarm can be issued via the computer unit if for example the battery voltage falls to the lower limit value Ul in too short a time in order for the battery to be considered reliable. The battery capacity can be estimated by means of the open cell voltage (OCV) of the battery in disconnected mode. The accuracy of the capacity estimate calculated in this way is dependent on the time the battery has been without charging or discharging, since the OCV is proportional to the acid density of the battery and thereby the state of charge of the battery. After approximately 24 hours, the capacity can be only roughly estimated (±20%), whereas after 120 hours the accuracy is ±5%.

Thus, in accordance with the present inventive idea, the computer unit 9 of the UPS in Figure 2 is adapted to estimate the capacity of the battery 1 on grounds of the battery voltage and its condition on the basis of the rate of decline of the voltage after charging, and to initiate an alarm to the user of the connected system when a given decline rate of the battery voltage during a given period of time is exceeded.

It is understood by one skilled in the art that the invention is not restricted to the examples given

above, but its different embodiments may vary within the scope of the ensuing claims.

Claims:

1. A method of controlling and maintaining the charge in an accumulator battery (1) in an uninterruptible power supply, which battery is disconnected from the load under normal conditions, c h a r a c t e r i z e d in that the voltage over the disconnected battery (1) is measured and compared to a predetermined minimum limit value (U1), that the battery is charged when its voltage has declined to the minimum limit value, and that the charging is discontinued when the battery has reached a certain state of charge.

2. A method as claimed in claim 1, c h a r a c t e r i z e d in that the charging is discontinued by lowering the charging reference of the charger (7) to a level at which no current is supplied to the battery (1).

3. A method as claimed in claim 1 or claim 2, c h a r a c t e r i z e d in that the charging of the battery (1) is effected in two steps, whereof the first charging step is performed with a higher charging reference (Ux) to a predetermined value (Uy) of the battery voltage, and the second charging step is performed with a lower charging reference (Uz) during a predetermined time (th).

4. A method as claimed in claim 1, 2 or 3, c h a r a c t e r i z e d in that the condition of the battery (1) is estimated on the basis of the decline rate of the battery voltage after charging, wherein exceeding a given decline rate during a given period of time initiates an alarm to the user of the connected system.

5. An uninterruptible power supply comprising an accumulator battery (1), an inverter (2) for the

inversion of the battery voltage, switching means (4, 6) for altering the power supply to the load, a charger (7) for charging the battery, and a logic unit (9) for performing various control functions, characterized in that the logic unit (9) is adapted to monitor the battery voltage in disconnected mode and to compare it to a predetermined minimum limit value (U1), to charge the battery when its voltage has declined to the minimum limit value, and to discontinue the charging when the battery has reached a certain state of charge.

6. An uninterruptible power supply as claimed in claim 5, characterized in that the UPS is adapted to discontinue the charging by lowering the charging reference of the charger (7) to a level at which no current is supplied to the battery (1).

7. An uninterruptible power supply as claimed in claim 5 or claim 6, characterized in that the UPS is adapted to control the charging of the battery (1) in two steps, whereof the first charging step is performed with a higher charging reference (Ux) to a predetermined value (Uy) of the battery voltage, and the second charging step is performed with a lower charging reference (Uz) during a predetermined time (th).

8. An uninterruptible power supply as claimed in claim 5, 6 or 7, characterized in that the capacity of the battery (1) is estimated on the basis of the decline rate of the battery voltage after charging and to initiate an alarm to the user of the connected system when a given decline rate of the battery voltage during a given period of time is exceeded.

9. A method of controlling and maintaining the charge in an accumulator battery substantially as

hereinbefore described with reference to Figures 2 to 4 of the accompanying drawings.

10. An uninterruptible power supply substantially as hereinbefore described with reference to the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report) -10-

Application number
GB 9320079.8

Relevant Technical Fields

(i) UK Cl (Ed.L) H2H HAJ, HBCD

(ii) Int Cl (Ed.5) H02J 7/02, 7/04, 7/06, 7/08, 7/10, 7/12, 9/00, 9/02, 9/04, 9/06

Search Examiner
M J BILLING

Date of completion of Search
10 DECEMBER 93

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Documents considered relevant following a search in respect of Claims :-
1-3, 5-7

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
Y	GB 2248735 A	(GOLD STAR) eg. See Abstract	3, 7 at least
X,Y	GB 2091502 A	(ESQUIRE) eg. See Abstract, page 1 lines 12-79	1, 2 3, 7
X,Y	GB 2084817 A	(ELECTRO MATIC) eg. See page 1 lines 57-85	1, 2, 5, 6 3, 7
X,Y	GB 1349079	(AEROSPATIALE) eg. See page 4 lines 31-35	1, 2, 5, 6 3, 7
X,Y	EP 0209269 A2	(GILBERT) eg. See page 5 lines 8-40	1, 2, 5, 6 3, 7
X,P,Y	US 5185536	(EXIDE) eg. See Figure 2, column 3 lines 24-35 Published 9 February 1993	1, 2, 5, 6 3, 7

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).